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AN ANALYSIS OF THE ECONOMIC
EFFECTS OF U.S. ENERGY EFFICIENCY STANDARDS

by

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An Analysis of the Economic Effects of U.S. Energy Efficiency Standards

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ABSTRACT

The purpose of this study is to analyze the economic effects of Federally mandated energy efficiency standards on the market for home appliances. The analytical focal point of this thesis centers on representative studies and Congressional testimony supplemented by current articles and data. The benefits and costs of energy efficiency standard implementation are examined. Economic assumptions and key determinant factors that drive results, such as discount rate selection, provide the basis for objective comparison. The findings of this study support the need for Federal intervention in the home appliance market to alleviate economic market failures.

TABLE OF CONTENTS

I. INTRODUCTION

A. GENERAL

This study will evaluate the economic effect of Federally mandated energy efficiency standards for hot water heaters, one of thirteen home appliances affected by the National Appliance Energy Conservation Act of 1987. Economic studies and models utilized in the development of the Act will be instrumental to the analysis. While product decisions can be traced to non-economic factors, such as technical feasibility and politics, this study will focus on the economic factors inherent in product design choice.

The National Appliance Energy Conservation Act of 1987 was a culmination of a lengthy legislative process influenced throughout by government, industry, consumer, state and environmental concerns. Key players included the Department of Energy, State energy officials, appliance industry representatives, state and local utility management, environmental and consumer advocacy groups and research institutes. All had a stake in passing the Act, which had a direct effect on all aspects of the economic market for home appliances.

With the passing of time, the effects of the 1987 mandatory government regulation on home appliances can be explored. Enforcement of standards and the resulting benefit/cost tradeoffs can also be examined. Moreover, the economic effect of government intervention in a free market can be evaluated.

B. RESEARCH QUESTIONS

1. What economic models were used to determine energy efficiency standards for hot water heaters?

2. Was benefit-cost analysis utilized in setting energy efficiency standards for hot water heaters?

3. How are energy efficiency standards enforced?

4. What effects, if any, have energy efficiency standards had on the hot water heater industry?

5. Should the government mandate energy efficiency standards for hot water heaters?

C. METHODOLOGY

1. A review of ongoing research in the area of energy efficiency standards focused on benefit-cost analysis and comparability of assumptions utilized in the studies.

2. A literature search included data available through the Energy Information Administration (DOE), appliance trade organizations and utility management organizations as well as supporting documentation from the National Appliance Energy Conservation Act of 1987.

3. Personal interviews with key players in the passage of the Act were conducted to supplement existing literature sources. Additional interviews with Department of Energy and home appliance industry trade representatives provided the assessment of standard enforcement effectiveness.

D. SCOPE

This study will focus on currently available data and supplemental personal interviews to forward the economic study of energy efficiency standards in the hot water heater market. The intent of this study is to evaluate historical and current data with the objective of providing a correlated framework to better understand economic factors in governmental regulation of free economic markets.

E. ORGANIZATION

This study will begin with an in depth look at the background for government mandated energy efficiency standards for home appliances. From 1982 until passage of the Act in 1987, testimony of Congressional hearings and media coverage of the issue provided an interesting and comprehensive outline of the forces and influences involved. Next, the economic models utilized in standard development are evaluated. This is followed by an assessment of the impact that standards had on the market for home appliances, using water heaters as a representative of the 13 appliances affected by standardization. A look at enforcement and certification procedures and their costs will follow. Finally, conclusions and recommendations will be offered highlighting the need to assess all of the benefits and costs of governmental regulatio.. or standardization before implementation.

II. BACKGROUND

A. GOVERNMENT REGULATION

Federal regulation via standardization in the hot water heater market seeks to address the issue of energy efficiency and conservation. By mandating standards, the government assumes that both the market and the consumer will not make economically efficient decisions in the production and purchasing of hot water heaters. To ensure efficient usage of scarce resources, the government invokes standards.

Those who advocate government regulation suggest that mandatory standards allow a more consistent national policy. Another argument for regulation is that it is a better alternative than government assumption of private production functions.

The opposing view is that regulation of free markets does not allow the forces of supply and demand to work. This view also suggests that public processes are inherently inefficient and that regulation itself results in inefficiency. Private industry has the capability to gain real-time information quicker and therefore respond sooner then public or governmental agencies. Another argument against regulation of free markets is that the gains possible are small compared to the inefficiencies that may result. [Ref. 1:pp. 190-191]

B. EXPECTED MARKET OUTCOME

An efficient market should allow consumers to make informed purchase decisions based on tradeoffs between performance attributes and life cycle costs. In the case of water heaters, performance attributes are synonymous with energy efficiency improvements, such as heat pumps, better insulation and timers that conserve power during periods of non-use. Life cycle costs would reflect operating costs over the life of the equipment. Ideally, the consumer would expect a balance between higher performance attributes and lower life cycle costs and vice versa. Purchase cost can be a factor in the purchase decision but should be secondary to life cycle costs. This depends on consumer satisfaction and awareness of the pay back period or time required for operating savings to recover purchase costs.

In the home appliance market, and more specifically the market for hot water heaters, the expected market outcome is dependant on consumer type. The three consumer categories are first time buyers, retrofit or replacement buyers and third party buyers (builders or contractors). Studies suggest that in purchase decisions for some consumer categories, purchase costs override life cycle costs and performance attributes as the dominant factor in the purchase decision.

Third party consumers, such as builders and contractors, account for almost 80% of the market for home appliances. A 1980 Builders Home Survey revealed that builders and contractors focus on purchase cost as their main determinant in purchase decisions involving home appliances. [Ref. 2:Abstract]

> Analysis of the resulting 406 questionnaires indicated that builders were primarily responsible for brand selection. These choices were made primarily without regard for energy efficiency of the product. A similar apparent lack of consideration of energy efficiency during brand and model selection was found among home-buyers and specialized subcontractors.

The builder or contractor's main concern is purchase cost. This effects their profit margin, while life cycle costs do not. Life cycle costs are passed on to the eventual owner of the property. It does not make good business sense for builders and contractors to independently incur unrecoverable costs that make them less competitive in comparison to other builders. Even the Federal government is a third party consumer. Federal housing projects typically employ the same philosophy as builders, looking at purchase cost as the main factor in purchase decisions. This is ironic in that the Federal Government has long term considerations, as both a landlord and bill payer. This warrants examining the tradeoffs between performance attributes and life cycle costs to reduce costs in the long run. One possible explanation is that annual budget constraints focus management on purchase cost instead of life cycle costs.

A Government Accounting Office Report, dated September 16, 1981, highlighted the Federal Housing problem. [Ref. 3:pg. 135]

Normal market forces, in themselves, do not encourage the installation of the most energy efficient and cost effective equipment. The developer of such housing, rather than the ultimate homeowner, normally selects the heating and cooling equipment installed. Developers are primarily concerned with installing equipment that adequately performs the function at the least cost.

Low income consumers are also particularly sensitive to purchase cost. In spite of the Federal Trade Commission's extensive efforts since 1975 to emphasize estimated life cycle operating costs, low income consumers consistently react to purchase cost as their main consideration. The FTC's Energy Guide program provides them with critical data for cost and energy efficiency comparisons, but initial outlays continue to be the dominant decision factor. [Ref. 4:pg. 27] Manufacturers are sensitive to the third party consumer and low income consumer. In absence of regulation, they would continue to provide low efficiency and low cost products for this significant market share.

Conversely, retrofit and other first time consumers appear to react positively to the estimated savings in operating costs and purchase more energy efficient water heaters. These consumers realize that the benefits outweigh the up-front costs of performance attributes and act in their best interest to reduce future and overall costs.

The assumption that higher energy efficiency leads to proportionately higher energy savings can be in error. Lower consumer energy costs that are caused by higher efficiency appliances can cause consumers to use more energy. For example, a consumer has a new energy efficient heater installed. Assuming monthly energy bills are reduced, the consumer has more discretionary income. The consumer decides to then increase the temperature setting in the house to have greater comfort, with his/her bill approximating the normal cost of the old system. This is an illustrative application of the economic theory known as the substitution effect, with a supporting income effect. [Ref. 5:pg. 94] A recent study, by Hurst and White, highlights this consumer behavior and outlines the difficulty of correlating economic savings from energy efficiency to consumer behavior. [Ref. 6:pg. 31] Conclusions from the study revealed that, on average, actual energy savings are less than predicted from engineering estimates associated with energy efficiency audits. Further, there was a significant variation in actual energy savings between households and the relationship between predicted actual savings.

The battle between free market forces and national standard advocates centers on whether the consumer will freely make energy efficient choices or require the government to shape his choices to energy efficient products via standards, taxes or incentive programs.

In view of the complex relationships between consumer/market behavior and product energy efficiency, it is necessary to examine the underlying reasoning for implementation of Federal energy efficiency standards. A closer look at the legislative history of energy efficiency standards is necessary to provide the background for subsequent discussion.

C. HISTORY OF ENERGY EFFICIENCY STANDARDS

To understand the development of the National Appliance Energy Conservation Act of 1987, it is necessary to highlight the chronological steps of the legislative and executive process which shaped the Act. The issues and theories forwarded by industry, government and environmental concerns provide an understanding as to the forces and influences involved in the regulation of private industry by the federal government.

1975 Congress passes the Energy Policy and Conservation Act Act, which requires home appliances to have energy efficiency rating labels affixed to appliances for consumer benefit.

1976 California passes a tough comprehensive law requiring energy efficiency standards for all home appliance sold in the state. Other states begin developing varying standards for home appliances.

1978 Congress orders the Department of Energy to set efficiency levels for 13 home appliances. Provisions for this action were outlined in the Energy Policy and Conservation Act of 1975.

1981 DOE blocks standards by issuing a "no standards" standard. (Standard is that no standard is required.) The National Resource Defense Council (NRDC) files suit in a Washington D.C. court to overturn this standard. (NRDC eventually wins the case.)

1981-1986 Hearings convene before both the House and Senate Energy Committees. Witnesses testify representing a wide range of views on the issue of Federal energy efficiency standards. Witnesses can be categorized into five separate groups; Government, industry, state, utility, and environmentalist/consumer advocate. A summary of each group's position on Federal regulation of the energy efficiency of home appliances follows.

1. Government View

Top Department of Energy officials pursued a unified approach throughout the legislative process. They consistently resisted efforts by industry, utility and environmentalist/consumer advocate groups to force them to develop and administer a national standardization program for home appliances. The government position was consistent with the political and economical ideology of the Reagan administration, which generally advocated allowing free market forces to determine market equilibrium without government regulation. When forced by law (1975 ECPA) to develop standards, the Department of Energy adopted a "no standard" standard which complied with the law but did not make the government the regulator of the home appliance market. The government's position was based on the assumption that the costs of standard development and administration were too high when existing market forces were working.

The Government Accounting Office conducted a study of the "no standard" standard development and justification process in 1982. [Ref. 4:pp. i-ii] The report concluded that basic assumptions in the Department of Energy's analysis were flawed. Specifically, they faulted the assumption that consumers purchase higher efficiency appliances in the face of rising energy costs.

> The analyses contain an unvalidated key assumption, are inconsistent in their treatment of the effects of market forces, and use high energy price projections. The potential impact of this decrease is to decrease the energy savings from, and increase the costs of, appliance standards.

Water heaters were cited as an example of the lack of a strong relationship between the price of energy and energy efficiency. For the period 1972 thru 1978, the price of gas increased 65% while the energy efficiency rating of water heaters went up by only 1.7%. [Ref. 7:pg. 153]

By issuing the "no standards" standard, the Federal Government preempted State energy efficiency regulation. Congressional hearings now reflected growing support for Federal regulation among a diverse coalition of industry, environmentalist/consumer advocate and utility groups, forcing the government to rethink its position. The government reluctantly began to evaluate standardization programs again. However, the Department of Energy was still resisting the role of national regulator of energy efficiency in home appliances as late as 1986. Further reasons for objecting to Federal regulation arose because of the difficulty of setting standards for multiple climate zones, foreign competition issues, possible impacts on product design, reduction in product lines/employment and increased purchase cost to consumers.

Congressional support continued to grow, in spite of DOE's view, providing the impetus for overriding Reagan's pocket veto of the 1986 National Appliance Energy Conservation Act and eventually contributing to the bill's passage in 1987.

2. Industry View

Home appliance industry representatives started out resisting _all_ regulation as a needless intrusion by regulatory agencies into a market that they felt efficiently responded to consumer demand. Arguments centered on the premise that consumers made informed and efficient choices on energy issues. An example of this was a statement made by Robert M. Gants, a Vice President of the Association of Home Appliance Improvement. In a March 18, 1986 article published in the Christian Science Monitor, he stated that "the home appliance market had become 40 to 70 percent more efficient in response to competitive free market forces and thus did not need regulation". [Ref. 8:pg. 6]

This resistance to regulation eroded quickly in view of State development and implementation of varied energy efficiency standards. Faced with an increasingly complex and costly problem of complying with different standards in different States, the industry realized its only feasible choice was to support Federal efficiency standards. The testimony of David A. Corcoran, President of American Supply Association, highlights some of the problems appliance industry companies faced. [Ref. 9:pg. 218-219]

> Massachusetts has a standard for hot water heaters. The only heaters that are sold are those that meet or exceed the standard. I cannot sell water heaters in the adjacent State of Rhode Island, a State without a

> standard. In order to do so, I would have to stock multiple inventories to meet the demand in both States. Multiple inventories increase my cost to the point where I cannot justify the additional overhead. Product costs are increased because of increased handling and inventory expense, costs which have no bearing on the energy efficiency of the product.

Practical issues of efficiency of production, design, inventory and cost factors drove the industry to conclude that Federal standards were better than multiple State standards.

Other costs of complying with multiple State standards were raised by Robert B. Gilbert, representing the Air-Conditioning Refrigeration Institute. [Ref.10:pg 69]

> Our industry needs national economies of scale in order to produce the most efficient product at the lowest cost to the consumer. When the national market is chopped into small pieces, the whole process becomes chaotic, terribly expensive, inefficient and very risky. More frequent model changes will mean more frequent redesign, retooling and shorter production runs. The result will be higher costs and eventually higher prices for the consumer, perhaps 10 to 20 percent per unit. The result probably also will be the inability of some companies to maintain a foothold in the market and survive. In short, if we are going to be regulated, and we are being regulated today in more and more States, then the only way to go is Federal regulation.

Home appliance industry advocates found themselves aligned with a diverse coalition of environmentalist/consumer advocate and utility groups seeking the same goal. The strength of this coalition had a positive effect on Congress and helped to overcome government opposition to Federal regulation.

3. States View

State officials and lobbyists for State Government Associations worked hard in opposition to Federal energy efficiency standards. Federal standards, if passed, would supersede State regulations, removing regulatory and legislative power from State governments. New York and California led the nation in energy efficiency programs. Both had large energy conservation staffs and extensive resources involved in development of energy efficiency standards. They considered their energy programs an important contributor to national energy conservation. With high State populations and high energy demand, these States felt that they were best qualified to manage energy programs at the State level. Other States modeled their energy programs after these with modifications based on climate and population considerations. Most States adhered closely to the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) Standards which were generally accepted across the nation as the minimum standard for being considered energy efficient.

Proponents of State regulation were strongly opposed to the Department of Energy's issuance of the "no standard" standard, which in effect preempted existing State efficiency standards. The multiple State standards caused industry, environmentalist, consumer and utility groups to band together and help influence passage of Federal Standards in spite of State objections.

4. Environmentalist/Consumer Advocate View

Throughout the legislative process, environmentalist and consumer advocate groups supported the need for national standards for efficiency in home appliances. As many as 41 different organizations were members of the Coalition for Federal Appliance Efficiency Standards. The Audubon Society, Sierra Club, Consumers Union and National Consumers League were among these. The major proponent of the environmentalist and consumer viewpoint was the Natural Resources Defense Council. David B. Goldstein, a Senior Staff Scientist with the Natural Resources Defense Council, testified before Congress as to the environmental impacts that result from national standards. [Ref. 11:pg. 3]

> Reductions in energy use can lead to substantial reductions in air pollution. For example, the California Energy Commission calculated that its refrigerator standards would reduce emissions of nitrogen oxides by 5% statewide and emissions of sulfur oxides by 20%. These two pollutants are major precursors to acid rain.

In the area of consumer benefits, research by the American Council for An Energy Efficient Economy (ACEEE) showed that the standards proposed in the 1987 National Appliance Energy Conservation Act could save 22,000 megawatts of peak electric power by the year 2000. [Ref. 11: pg. 11]

> The ACEEE study shows a savings to consumers of over $28 billion nationwide, or a cost reduction of over $250 for an average American family. Money saved by consumers on their energy bills will be spent on other activities, fostering job creation and economic growth.

The environmental and consumer groups were instrumental in rallying support for national standards. Their arguments centered on savings and cost avoidance with a general rationalization that national standards were a win-win solution for all.

5. Utility View

Groups representing utility views, such as the American Public Power Association and the Edison Electric Institute, strongly supported national energy efficiency standards. With national standards, more uniform products would allow better estimates of future energy demand. Considering the capital investment decisions and dollars involved, any reduction in energy demand could defer expensive utility plant expansion. A 1986 study conducted by Lawrence Berkeley Laboratory concluded that standard implementation in Nevada could reduce the need for new power plants by 30 to 60 percent. [Ref. 12:pp. 147-160] This is significant in that erroneous energy demand forecasting has cost the national utility industry an estimated $20 billion in wasted investment, according to DOE analysis. [Ref. 11:pg. 123]

Utility proponents also had a significant interest in national standards from another perspective. Seeking to influence consumer behavior, utilities had developed consumer rebate programs rewarding efficient appliance purchasers with discounts on their monthly bills. [Ref. 13:pg. 2]

> Rebates have been extremely successful and cost effective way for utilities to "purchase" additional

capacity on the demand side, but they are insufficient by themselves. For one thing, rebates tend to go to middle and upper income consumers, with lower income families often limited to used appliances or rental housing, in which appliance costs emphasize first costs rather than life cycle costs.

According to Larry Hobart, Executive Director for the American Public Power Association," national standards would be a more efficient and equitable method of achieving energy conservation then the rebate." [Ref. 13:pg. 2]

Utility industry leaders joined with environmental, consumer, and appliance industry advocates to help pass the 1987 National Appliance Energy Conservation Act.

Reaction

Media interest in the 1987 National Appliance Energy Conservation Act focused on estimated energy savings that would result from the bill. While savings varied depending on the source, it is interesting to note the lack of any coverage of the estimated cost to develop, administer or enforce the national standards.

The most critical view of the bill was forwarded by Doug Bandow, a Senior fellow at the Cato Institute. He sighted three effects that would result from passage of the bill. [Ref. 14:pg. A-5] First, energy guide labels allow consumers to be informed and make choices. Standards would restrict choices, notably on the lower end of the energy efficiency and cost scale. Costs would increase and unduly effect low income consumers, who value low purchase cost rather than operating life cycle costs as their main buying concern. Secondly, he refuted the utility industry argument that energy efficiency reduction in home appliances reduces energy usage. An increase in prices commensurate with low efficiency model discontinuation and built-in energy saving features would force consumers to hold on to older more in-efficient appliances. Also, if consumers purchase energy efficient models they would be more likely to purchase additional units since their energy bill would be lower. Finally, he recognized legitimate arguments for resolution of varied State standards but suggested federal standards are not the solution. He suggested that eliminating barriers to interstate trade would solve the problem.

The bottom line is that energy efficiency does not necessarily equate to cost efficiency. He supports a free market where consumers can make informed decisions.

D. SUMMARY

Over the period from 1975 to 1987, the United States government, State officials, utility management, lobbyists, and industry representatives waged legislative battles over the adoption of national energy efficiency standards for home appliances. The government began the struggle under the influence of "Reaganomics" and sought a hands off approach to economic markets. Testimony of Department of Energy Officials was consistent with this philosophy. State energy officials saw Federal standards as usurping their right to regulate within state boundaries. Trade industry representatives at first resisted support for Federal standards as restrictive of free market economic forces. The complexity of dealing with many different State standards led them to support Federal regulation as the lesser of two evils. Faced with unified support for Federal energy standards by environmental, consumer, industry and utility groups, the government reluctantly acquiesced.

Analysis of the positions adopted by the opposing sides in the struggle over national standards revealed a inconsistent approach in justifying or opposing standards. Savings dominated almost all aspects of proponent arguments and costs dominated opposing evaluations. In light of this, it is only fair to balance the benefits with the costs. Between the years 1979 and 1981, DOE spent over $15 million on standard development and testing. [Ref. 15:pg. 45] Harder to quantify is the cost effect on industry. Retooling, product discontinuation and redesign, unemployment, and other costs to the appliance industry should also be weighed.

Chapter III will provide a closer examination of the studies and models influential in the development of energy efficiency standards for home appliances.

III. MODELS AND STUDIES ANALYSIS

A. INTRODUCTION

What studies or models were influential in the legislative process that resulted in the 1987 National Appliance Energy Conservation Act? What assumptions were made about the market for home appliances and more specifically hot water heaters. To answer these questions several of the available studies are examined, concentrating on their assumptions, data, and estimates for cost and savings. While other studies or models exist, this thesis will utilize several representative studies/models as a framework to analyze the economic strengths and weaknesses of their approaches. In particular, The Department of Energy's 1982 Engineering Analysis Document provides an breakdown of estimated costs to the home appliance industry that could be attributed to standard implementation. The National Audubon Society Model State Energy Efficiency Bill and an American Council For An Energy-Efficient Economy Study examine estimated savings predicted under varying assumptions. These studies and others, along with the testimony of interested parties, contributed to the passage of the 1987 National Appliance Energy Conservation Act.

B. COMPONENTS

Program or project evaluation can take many forms. Internal Rate of Return, Payback, Benefit-Cost Analysis and Net Present Value Analysis are all methods that assist managers in the economic decision making process. Which method you prefer could be based on available data or assumptions you use. While these methods can help decision makers compare alternate projects, they also provide an excellent means for evaluating a new project against a baseline or status quo.

According to Ruegg and Petersen, selecting a method of economic evaluation is but one step in a ten step process. [Ref. 16:pg. 6]

1) Define the problem and state the objective
2) Identify constraints
3) Identify technically sound technologies
4) Choose method(s) of evaluation
5) Compile data and establish assumptions
6) Calculate measures of economic performance
7) Compare alternatives
8) Perform sensitivity analysis
9) Take into account unquantified effects
10) Make recommendations

While a comprehensive economic evaluation process should include all these areas, this study will examine two critical areas that influenced representative study outcomes - Step (4) Choose method(s) of evaluation and Step (5) Compile data and establish assumptions. These two areas provide a good comparison point between the different studies and allow questions to be raised as to the intent and purpose of each study.

C. COMMONALITIES

Many energy efficiency studies use the payback method as the preferred economic analysis method. This parallels business preferences to utilize the payback method. Over 70% of the businesses in the world use payback as their economic analysis tool. [Ref. 17:pg. 135]

The payback method usually takes one of two forms - simple payback or discounted payback. The major difference between the two is that the discounted payback method takes into account the time value of money.

The payback method appears to provide a good indicator of recovery of consumer first costs measured against equipment life. However, problems arise in expanding the payback evaluation to a national scale. If simple payback is used it will provide a quicker payback period then a more realistic discounted payback method. Also, the payback method does not deal with operational costs or savings after payback is realized.

It could be argued that a more appropriate economic evaluation method for a national economic issue is benefit-cost analysis. Whereas, the payback method would provide an indication of when investment costs where recovered, the benefit-cost analysis method should provide a total balance of all costs and benefits associated with a program or project.

Another reason to choose the benefit-cost method involves consumer behavior. Assuming consumer behavior is uncertain, with regard to energy efficiency optimization, the payback method does not provide a quantifiable evaluation point to assess the feasibility of whether or not standards should be implementated.

For example, in determining what the energy efficiency level should be, does a payback period of two years effect consumer choice? Is there a positive correlation between payback period and energy efficiency? In the home appliance market, market failures such as information failure, third party consumer purchasers and consumer welfare loss tend to prevent consumers from optimizing payback data.

With benefit-cost analysis, estimated costs can be weighed against estimated benefits to arrive at an analytical conclusion. However, care must be exercised in utilizing the benefit-cost economic evaluation. In setting efficiency standards, the point where marginal benefits just exceed marginal costs would define minimum standard levels. This point would be hard to identify but would approximate the least cost for the most benefit. This would address the issue of whether the government has set the standard too strictly or too loosely. Of course this argument is independent of political and technological issues, which would effect the objective balancing of costs and benefits. This is the case with home appliances as State and Congressional objectives influence the process determining energy efficiency standards. States want to maintain certain levels of energy efficiency standards and Congress wants to maximize dollar and energy savings.

Common to the different approaches in economic analysis is the balancing of <u>all</u> estimated or actual costs against estimated savings or resultant benefits. It is essential that assumptions made about costs and benefits be fair. Ideally, political and issue oriented overtones should be removed from the economic spectrum allowing an unbiased assessment of the benefits and costs of a proposed project or program.

D. DIFFERENCES

The apparent intent of each of the studies/models is to provide support or argue the case for a specific position or view. Whether you support or oppose implementation of Federal energy efficiency standards, the range of possible assumptions allows some latitude in your approach.

For example, if the discount rate used to adjust future costs and benefits varies significantly between studies, than the conclusions drawn from the resultant data could be markedly different. If one analysis used a 0% discount rate while another used 5%, the former project would appear to provide greater savings than the latter. [Ref.18:pg 691]

> Often there are few or no benefits in the early years, but benefits increase as the project is brought into full development. Thus the effects of discounting the costs will not be as great as the discounting of benefits, because the costs tend to occur early. Consequently, any group or organization with a real stake in promoting a project will want to use a low discount rate.

In examining the following models and studies, varied assumptions, such as discount rate selection and treatment of cost and benefit data, will be analyzed with the goal of providing an objective look at the data presented. Only by examining the total spectrum of costs and savings can one net the true potential of a program or project.

E. DEPARTMENT OF ENERGY STUDY

The Consumer Products Efficiency Standards Engineering Analysis Document was the only study to attempt to quantify the home appliance industry costs associated with implementing the energy efficiency standard. While standard proponents and the Government Accounting Office found fault with DOE's assumptions about free market efficiency [Ref. 4:pp. i-ii], it remains a source of important cost data essential to evaluating the costs of standards on the home appliance industry.

The study was completed by Arthur D. Little Inc., under contract to DOE, and focused on cost-efficiency relationships based on four general areas: [Ref. 19:pg. C-1]

1) Total industry-wide investment required to meet various efficiency levels by product type.

2) Materials required to meet various efficiency levels by product class.

3) Average per unit cost change necessary to meet specified energy levels by product class.

4) The relationship between price and efficiency level by product class.

In the case of water heaters, manufacturers costs to implement higher efficiency standards were tabulated in the two major product classes of gas and electric hot water heaters.

Key assumptions utilized in the study were: [Ref.19:pg C-1]

1) Production volumes were assumed to remain constant at 1978 levels for each product class.

2) Design options selected for analysis were based only on technologies which were currently available. (1980)

3) Only design options consistent with existing DOE test procedures were considered.

4) Lead times available for implementing design changes required to meet efficiency levels analyzed are large enough so that no significant increase in engineering staff will be required.

Assumption three caused the most problems for DOE because it excluded heat pumps from design options. DOE did not have heat pump test procedures in place at the time of the study. Heat pumps were a major energy efficiency option that proponents of standards felt essential to any analysis of costs and savings.

In the case of hot water heaters, design options involved four specific improvements which would individually raise energy efficiency levels. [Ref. 19:pp. D3-7 and 8]

1) Improved insulation

2) Increased flue heat transfer and reduced main burner rate

3) Retooled jacket top

4) Heat traps

These improvements were to be incorporated from a baseline product efficiency level, based on data from lab tests, manufacturers and the State of California's list of certified water heaters. [Ref. 19:pg. D3-8]

Efficiency was measured in two ways - recovery efficiency and standby loss. First, recovery efficiency was calculated by dividing the ratio of useful energy output by the energy utilized in increasing the water temperature from 70 degrees to 160 degrees F. Residential water heaters are normally set at temperatures lower than 160 degrees. Water must travel varying distances thru pipe to reach the user. This creates a need for different peak heating levels. The key measurement therefore is the energy required to heat the differential of 90 degrees.

Secondly, standby loss was calculated. Standby loss is the amount of energy required to maintain 160 degrees F as a percent of the capacity of the tank per hour. These two inputs were used in calculating the energy required to heat the assumed national daily household average of 64.3 gallons of water. The result was called the Energy Factor (EF). [Ref. 19:pg. D3-1]

> The energy factor is the ratio of the useful output of the water heater expressed as the energy required to provide 64.3 gallons of water on a daily basis through a 90 degree differential, divided by the estimated daily energy consumption of the water heater calculated

from the recovery efficiency and standby losses as described above.

Complicating factors that required the narrow definition of the energy factor were varying tank sizes and different insulation materials. The purpose of utilizing the energy factor appeared to be providing a fair analysis of heater energy efficiency across product lines. Manufacturers appeared to agree, as evidenced by the lack of significant protest to energy factor levels proposed by this Engineering Analysis.

To analyze manufacturer's costs associated with standard implementation, six levels of efficiency were correlated to related energy factors (EF). The higher the efficiency level the higher the EF rating, as shown in Table I. [Ref. 19:pg. D3-24]

TABLE I
ENERGY FACTORS RATING

Efficiency Level	GAS (EF)	ELEC. (EF)
Baseline		
1	49.5	78.3
2	57.8	83.6
3	58.4	87.1
4	60.1*	88.2
5	60.7#	91.6@
6		92.1+

Notes * Level 2 with heat trap
Level 3 with heat trap
@ Level 3 with heat trap
+ Level 4 with heat trap

Of note, the actual energy factors set by the 1987 National Appliance Energy Conservation Act were higher than these. Gas heaters were to achieve a 62 (EF) as compared to the highest level in the study of 60.7 (EF). Electric heaters were to achieve 95 (EF) as compared to 92.1 (EF). [Ref.20:pg 30]

Redesign, retooling, plant expansion and other additional manufacturing costs were estimated based on an industry structure of three larger and five medium firms. This assumed industry structure is shown in Table II. [Ref. 19:pg. D3-13]

TABLE II
INDUSTRY STRUCTURE

	NUMBER OF MANUFACTURER	PRODUCTION VOLUME (Units/Year)	
		ELECTRIC	GAS
Large Manufacturer	2	590,000[1]	630,000
	1	530,000[2]	630,000
Medium Manufacturer	5	196,000[1]	205,500

Small manufacturers, defined as firms having sales below one percent of the market, were not included. No general manufacturing approach could be identified for these firms because of the wide variability in their approach to manufacturing. [Ref. 19:pg. A-2]

For evaluation purposes, all costs were collected into four categories - investment, materials, labor and purchased components.

1) Investment-required investment in capital equipment, tooling, plant and service/parts/ engineering/literature/inventory in thousands of dollars per manufacturer necessitated by increasing efficiency levels.

2) Materials-required changes in weight in the various materials from which components of the product are or were made expressed in pounds.

3) Labor-labor changes in minutes per appliance necessitated by efficiency level increases.

4) Purchased Parts-changes in purchased parts in dollars per appliance necessitated by efficiency level increases. Certification and enforcement costs (dollars) have been shown on a per unit basis as a purchased part using DOE estimates.

Table III shows the Summary costs per unit associated with standard implementation. [Ref. 19:pg. D3-23]

TABLE III
PRODUCT TYPE 3: WATER HEATERS
SUMMARY COST PER UNIT

		GAS		ELECTRIC			GAS		ELECTRIC	
L		1.82	1.82	1.09	1.09		2.19	2.19	1.82	1.82
M		2.94	3.16	2.19	2.42		4.07	4.33	6.75	7.23
P		.11	.11	.11	.11		5.11	5.11	.11	.11
I	1	.05	.12	.06	.13	4	.19	.27	.23	.33
T		4.91	5.21	3.45	3.76		11.55	11.90	8.92	9.49
F		6.73	7.14	4.73	6.15		15.62	16.30	12.22	13.00
L		1.82	1.82	1.82	1.82		2.19	2.19	2.19	2.19
M		4.07	4.33	4.41	4.75		6.16	6.54	5.56	5.97
P	2	.11	.11	.11	.11	5	5.11	5.11	5.11	5.11
I		.18	.25	.19	.19		.19	.26	.23	.31
T		6.18	6.52	6.53	6.87		13.65	14.12	13.08	13.58
F		.47	8.93	8.94	9.42		18.70	19.35	17.93	18.60
L		1.82	1.82	1.82	1.82				2.19	2.19
M		6.16	6.54	5.56	5.97				6.75	7.23
P	3	.11	.11	.11	.11	6			5.11	5.11
I		.19	.27	.23	.31				.23	.33
T		8.26	8.74	7.72	8.21				14.28	14.85
F		11.35	11.97	10.56	11.25				19.57	20.34

KEY:
L = Labor; M = Materials;
P = Purchased Parts;
I = Investment; T = Total
F = Ex-factory Cost (F = 1.37T)

NOTE:
Data for large manufacturer is in the left column of each block and for medium manufacturer in the right.

Imbedded in the cost figures is an .11 cents per unit DOE estimate of certification and enforcement program costs that would be assessed to manufacturers.

Utilizing the data in Table III, a rough dollar estimate of additional costs to the manufacturer can be calculated. These costs are the investment, material, labor and purchased part costs that manufacturers would incur with the adoption of energy efficiency standards. In the case of gas water heaters, the estimated added cost to the manufacturer is just under $56 million. This is based on efficiency level five cost data multiplied by the assumed industry production volume figures from Table I. For electric water heaters, the added cost to manufacturers is just under $54 million, based on efficiency level six cost data multiplied by the assumed industry production volume figures in Table I. These amounts are significant in themselves for they are but one of 13 appliances that were affected by Federal energy efficiency standards.

An argument could be made that manufacturers would have incurred these costs anyway in complying with proposed State regulation that was being drafted at the time, thus making an assessment of manufacturer's costs a moot point. This argument does not adequately address the scope of the problem or provide all the data for a fair and objective decision to be rendered.

For example, if a town wanted to build a park and had several alternatives with different costs and options, the city planners and taxpayers would want all available data concerning costs and potential benefits to be analyzed before making a decision. Even if the one alternative was the obvious choice, in fairness to all views, economic evaluation based on all estimated costs and benefits would be a logical and defendable position.

Table IV shows the incremental changes in efficiency, price and estimated energy usage inherent with the design options. [Ref. 19:pg. D3-24]

The projected energy savings was a straight line calculation based on the annual energy demand. For electric water heaters, savings was calculated by dividing 510,730 (kwh) by the (EF). Gas heaters used 1740 (10 to the 6th power BTU) divided by (EF). [Ref. 19:pg. D3-1] The data suggests a linear linkage between efficiency levels and reduced energy demand. This may not be the case, as consumers may choose to use more energy with newer more efficient products. This substitution effect and a discussion of consumer behavior is analyzed in Chapter II. The Consumer Products Efficiency Standards Engineering Analysis Document appears to provide a good estimate of manufacturing costs inherent to energy efficiency standard implementation. What it does not address are the operational and maintenance costs associated with the different efficiency level products. This data would be

TABLE IV
PRODUCT TYPE 3: WATER HEATERS
DESIGN OPTIONS/ENERGY FACTOR/YEARLY ENERGY CONSUMPTION
PRODUCT CLASS

EFFICIENCY LEVEL	GAS		ELECTRIC	
Baseline Unit	40.0	40.0	52.0	52.0
	203.0	203.0	164.0	164.0
	47.9	47.9	78.3	78.3
	36.3	36.3	6522.7	6522.7
1	125.0	125.0	13.0	13.0
	213.8	214.4	171.6	172.2
	57.9	57.8	83.6	83.6
	30.1	30.1	6109.2	6109.2
2	125.0	125.0	1.0	1.0
	216.5	217.3	178.3	179.1
	58.4	58.4	87.1	87.1
	29.8	29.8	5863.7	5863.7
3	125.0	125.0	1.0	1.0
	221.2	222.2	180.9	182.0
	59.0	59.0	87.7	87.7
	29.5	29.5	5823.6	5823.6
4	1245.0	1245.0	1.0	1.0
	228.3	229.1	183.5	184.8
	60.1	60.1	88.2	88.2
	29.0	29.0	5790.6	5790.6
5	1245.0	1245.0	14.0	14.0
	232.9	234.0	192.7	193.8
	60.7	60.7	91.6	91.6
	28.7	28.7	5575.7	5575.7
6			14.0	14.0
			105.3	196.6
			92.1	92.1
			5545.4	5545.4

Design Options:

1) Improved Insulation
   a) Increase Thickness
   b) Foam Insulation
2) Increase Flow Heat Transfer and Reduce

   Main Burner Rate
3) Top retooled to Reduce

   Mounting Lose
4) Heat Trape
5) Reduce Pilot Rate

KEY:
CAPACITY-DESIGN OPTIONS
PRICE
EFFICIENCY
YEARLY ENERGY CONSUMPTION (KWH OR MILLION STU)

NOTE: Data for large manufacturers is in the left column of each block and for medium manufacturers in the right.

important to determining the total costs attributable to standardization.

F. NATIONAL AUDUBON SOCIETY MODEL BILL

In an effort to spur State adaptation of energy efficiency standards, the National Audubon Society developed a model bill. The National Audubon Society had an interest in environmental issues that focused on power plant construction, energy exploration, development and conservation. In their view, energy efficiency standards would reduce the estimated need for these.

Other benefits would also result from support for standards. [Ref. 21:pg. 188]

> Efficient appliances mean that less air pollution will be released from home furnaces, less acid rain will be generated by electric utilities, and less nuclear waste will be produced that some day may escape into the environment.

When the push for Federal standards began, the Audubon Society supported it fully using their State Model Bill as a reference. They utilized a computer model to generate savings figures resultant from standards. Savings of 4 to 8 large 1000 megawatt power plants would be saved from construction. Consumer savings of 13 to 26 billion dollars were also estimated to occur through the passage of energy efficiency standards. [Ref. 21:pg. 191] Their logic was that consumers, the environment, the utilities, and the manufacturers would all benefit from standards.

The following assumptions were used in the computer model:

1) A zero discount rate was used to adjust future savings.

2) Savings projections were calculated through 2005.

3) Annual average power, not peak, were used in the calculations.

Assumptions 1 and 2 tend to increase the possible savings relative to other comparative studies, such as Geller [Ref. 22:pg. 10]. First, the zero discount rate is biased. It emphasizes the highest possible savings figures, as discussed earlier in this chapter. Second, with a longer period of time, the Audubon model would show greater overall savings then other studies. The length of the study could be questioned from a viewpoint of how predictable energy prices would be for so far into the future. The third assumption assumes that power plants saved are operating at 60% capacity. [Ref. 21:pg. 193]

> The Audubon computer model does not distinguish between peak and average power. Consequently we have assumed that the annual electricity savings are spread out uniformly over the year deriving an estimate of the number of power plant equivalents that will be eliminated by the proposed standards. In fact the savings from S. 2781 (Standards) would come in the form of peaking plants rather than base load plants.

This assumption does not address the question of whether standard implementation will permanently eliminate the need for the power plants or just help delay their need. Given that they will be eventually needed, the cost avoidance or savings attributed to not building them cannot be accredited to energy efficiency standard implementation alone. It would apply if one discounted the future savings to calculate the present value.

The National Audubon Society Model identifies savings. It appears designed, by the assumptions chosen, to make a case for standards as a way to avoid power plant construction, environmental exploitation, development and use. It does not appear to provide objectivity in a balanced approach to analyzing costs and benefits.

G. AMERICAN COUNCIL FOR AN ENERGY EFFICIENT ECONOMY STUDY

The American Council For An Energy Efficient Economy (ACEEE) is a non-profit organization that supports energy conservation. Howard S. Geller, a Research Associate for the group, provided a comprehensive study of energy efficiency savings possible through adoption of Federal standards.

Beginning in 1983, Geller analyzed benefits and costs associated with efficiency standards. His ACEEE sponsored study utilized DOE costing data. Because of this, energy saving design options, such as heat pumps, were not used. The importance of new efficiency equipment was not ignored by Geller as he utilized the heat pump to illustrate cost and efficiency relationships. [Ref. 23:pg. 143]

> The major gain in electric water heating efficiency was made possible by the development of the heat pump water heater (HPWH). This device functions like a refrigerator or air conditioner, using a compressor to move heat from a cooler to a warmer region.

Heat pump water heaters made a significant difference in energy consumption and saving figures. [Ref.23:pg 143]

Based on field tests in Madison, WI, the top-rated HPWH consumes only about 35% as much electricity as the standard electric water heater of late 1970's.

Higher energy efficiency features, such as the heat pump, caused the initial cost of newer appliances to be an estimated four to five times higher than regular water heaters. Table V shows the representative gains in efficiency in relation to increased first costs, simple payback period and return on investment. [Ref. 23:pg. 168]

TABLE V
REPRESENTATIVE GAINS

PRODUCT	MODEL	INCREASE IN EFF FM STND	INCREASE IN FIRST COST FM STD	SIMPLE PAYBACK YRS	REAL RETURN
Gas Wh	Amana	73%	$350	7.1	17%
Elec HPWH	Dec	182%	$1200	7.1	12%

These illustrative models were the top of the line at the time and thus, according to Geller, reflect the worst case scenarios for longer payback and higher first costs to the individual consumer. The calculations incorporated average national energy prices and DOE forecasted energy demand figures along with average household usage. (Geller, 1986)

Geller published a comprehensive update to his 1983 study in 1986. [Ref. 22:pp. 1-13] To illustrate the national scope of his study Tables VI thru Table X are shown. [Ref. 22:App] They reflect energy savings and economic savings for hot water heaters. Also included is Geller's comparative analysis of energy and economic savings between 8 of the thirteen home appliances affected by standards.

Assumptions used in the analysis include:

1) The analysis considers energy use, first cost, and operating costs of products sold between 1986 and 2000.

2) The analysis includes the energy and dollar savings over the lifetime of products affected by standards sold by the year 2000.
3) The economic analysis is done in terms of constant 1985 dollars using a 5% real discount rate for equipment and energy costs in the future.

4) The extra first cost for more energy-efficient models is estimated based on constant cost increase per unit of energy savings.

5) Average residential energy prices in 1985, $0.078/kwh for electricity and $6.06/MBtu for natural gas, are used. Also, it is assumed that prices remain level in constant dollars; i.e.,prices do not rise faster (or slower) than inflation.

Factors specific to water heaters in the Tables included:

1) The water heater UEC values are based on a constant hot water demand of 43 gal/day for an average household (2.7 persons).

2) It is assumed that the shipment-weighted energy factor (EF) ratings in 1984 were 0.494 for GWHs and 0.836 for EWHs.

3) In the marketplace case, it is assumed that the average new product efficiency experienced during the 1978-1984 period continue in the future. The rates of increase are 0.4%/yr for GWHs and 0.6%/yr for EWHs.

4) In the standards case, it is assumed that the average new model is 5% more efficient than the minimum level the year that standards go into effect (1990).

5) The extra first cost for increasing the efficiency of water heaters is derived from the engineering analysis sponsored by DOE when it considered standards during the early 1980s. Increasing the

efficiency of EWHs is assumed to cost $3.70 per unit of EF or $0.09 per kwh/yr of savings. Increasing the efficiency of GWHs is assumed to cost $2.70 per unit of EF or $6.56 per MBtu/yr of savings.

6) Water heaters have a 13 year lifetime.

7) Water heaters have a peak-to-average load factor of 1.08.

8) Net savings are the savings in lifetime operating costs minus the estimated extra first cost as a result of imposing the efficiency standards.

9) The benefit-cost ratio is the value of lifetime savings divided by the extra first cost for consumers.

According to Geller's data, Electric water heaters offer the greatest energy savings, about 39% by the year 2000. Electric water heaters also provide the most economic net savings, 31% of the total, while Gas water heaters are second with 22% of the total. [Ref. 24:pg. 117] While these figures reflect great estimated savings, due to the substitution effect discussed in Chapter II, they will in fact probably be lower.

The resultant benefit-cost ratio is the highest for water heaters. Any amount over 1.0 would indicate that the benefits outweigh the costs. Electric and gas water heaters appear to offer the greatest net benefit with benefit to cost ratios of 8.14 and 8.67 respectively. Other appliances such as air conditioners and furnaces are closer to 1.0. If savings are overestimated due to the substitution effect and consumer welfare losses are factored in, the costs could outweigh the benefits for some products.

TABLE VI
APPLIANCE STANDARDS ANALYSIS
ELECTRIC WATER HEATERS - ENERGY SAVINGS

Year	Sales Projec. (1000)	Market Case UEC (kWh/yr)	Stand Case UEC (kWh/yr)	UEC Savings (kWh/yr)	Agg. Annual Savings (GWh/yr)	Cum. Lifetime Savings (TWh)	Agg. Lifetime Savings (TWh)	Cum. Lifetime Savings (TWh)	Agg. Peak Savings (MW)	Cum. Peak Savings (MW)
1986	3173	4312	4212	100	317	317	4	4	39	39
1987	3215	4286	4090	196	630	947	8	12	78	117
1988	3258	4260	3971	289	942	1,889	12	25	116	223
1989	3301	4235	3856	379	1251	3,140	16	41	154	387
1990	3345	4209	3744	465	1556	4,696	20	61	192	579
1991	3390	4184	3722	462	1566	6,262	20	81	193	772
1992	3435	4159	3700	459	1577	7,838	20	102	194	966
1993	3480	4134	3677	457	1591	9,429	21	123	196	1162
1994	3527	4109	3655	454	1601	11,030	21	143	197	1360
1995	3574	4084	3633	451	1612	12,642	21	164	199	1559
1996	3621	4060	3612	448	1622	14,264	21	185	200	1759
1997	3669	4036	3590	446	1637	15,901	21	207	202	1960
1998	3718	4011	3568	443	1647	17,548	21	228	203	2163
1999	3768	3987	3547	440	1658	19,205	22	250	204	2368
2000	3818	3963	3526	437	1668	20,874	22	271	206	2573

TABLE VII
APPLIANCE STANDARDS ANALYSIS
GAS WATER HEATERS - ENERGY SAVINGS

Year	Sales Projec. (1000)	Market Case UEC (MBtu/yr)	Stand. Case UEC (MBtu/yr)	UEC Savings (MBtu/yr)	Agg. Annual Savings (TBtu/yr)	Cum. Annual Savings (TBtu/yr)	Agg. Lifetime Savings (TBtu)	Cum. Lifetime Savings (Quads)
1986	3288	27.40	26.50	0.90	2.96	2.96	68	0.07
1987	3332	27.30	25.60	1.70	5.66	8.62	130	0.20
1988	3376	27.20	24.60	2.60	8.78	17.40	202	0.40
1989	3421	27.10	23.70	3.40	11.63	29.03	268	0.67
1990	3466	26.90	22.90	4.00	13.67	42.90	319	0.99
1991	3513	26.80	22.80	4.00	14.05	56.95	323	1.31
1992	3559	26.70	22.70	4.00	14.25	71.19	327	1.64
1993	3607	26.60	22.60	4.00	14.43	85.61	332	1.97
1994	3655	26.50	22.50	4.00	14.62	100.23	336	2.31
1995	3703	26.40	22.40	4.00	14.81	115.04	341	2.65
1996	3752	26.30	22.40	3.90	14.63	129.68	337	2.98
1997	3802	26.20	22.30	3.90	14.83	144.51	341	3.32
1998	3853	26.10	22.20	3.90	15.03	159.53	346	3.67
1999	3904	26.00	22.20	3.90	15.23	174.76	350	4.02
2000	3956	25.90	22.00	3.90	15.43	190.19	355	4.37

TABLE VIII
APPLIANCE STANDARDS ANALYSIS
ELECTRIC WATER HEATERS - ECONOMIC SAVINGS

Year	Value Agg. An. Savings (10^6 $)	Value Cum. An. Savings (10^6 $)	Value Lifetime Savings (10^6)	Unit Extra First Cost ($)	Agg. Extra First Cost (10^6 $)	Net Agg. Savings (10^6 $)	Net Cum. Savings (10^6 $)	Benefit-Cost Ratio
1986	24	4	221	9	27	194	194	8.14
1987	45	68	419	16	51	367	561	8.14
1988	63	132	596	22	73	523	1084	8.14
1989	80	212	754	28	93	661	1745	8.14
1990	95	307	893	33	110	783	2528	8.14
1991	91	398	856	31	105	751	3279	8.14
1992	87	485	821	29	101	720	3999	8.14
1993	84	569	788	28	97	692	4690	8.14
1994	81	650	756	26	93	663	5353	8.14
1995	77	727	725	25	89	636	5989	8.14
1996	74	801	695	24	85	609	6598	8.14
1997	71	872	667	22	82	585	7184	8.14
1998	68	940	640	21	79	561	7745	8.14
1999	65	1006	613	20	75	538	8283	8.14
2000	63	1068	588	19	72	516	8798	8.14

TABLE IX
APPLIANCE STANDARDS ANALYSIS
GAS WATER HEATERS - ECONOMIC SAVINGS

Year	Value Agg. An. Savings (10^6 $)	Value Cum. An. Savings (10^6 $)	Value Lifetime Savings (10^6)	Unit Extra First Cost ($)	Agg. Extra First Cost (10^6 $)	Net Agg. Savings (10^6 $)	Net Cum. Savings (10^6 $)	Benefit-Cost Ratio
1986	17	17	160	6	18	142	142	8.67
1987	31	48	292	10	34	259	401	8.67
1988	46	94	431	15	50	382	782	8.67
1989	58	152	545	18	63	482	1264	8.67
1990	66	218	618	21	71	547	1811	8.67
1991	64	282	597	20	69	528	2339	8.67
1992	61	343	576	19	66	509	2848	8.67
1993	59	402	556	18	64	492	3340	8.67
1994	57	459	536	17	62	474	3814	8.67
1995	55	514	517	16	60	458	4272	8.67
1996	52	566	487	15	56	431	4703	8.67
1997	50	616	470	14	54	416	5118	8.67
1998	48	664	453	14	52	401	5520	8.67
1999	47	711	438	13	50	387	5907	8.67
2000	45	756	422	12	49	374	6280	8.67

TABLE X
APPLIANCE STANDARDS ANALYSIS
ELECTRICITY SAVINGS SUMMARY

	Savings by 1995			Savings by 2000		
Product	Annual (TWh/yr)	Lifetime (TWh)	Peak (MW)	Annual (TWh/yr)	Lifetime (TWh)	Peak (MW)
Refrig	6.83	130	912	13.86	263	1,851
Freezer	1.36	28	178	2.59	54	340
Wat. Ht.	12.64	164	1,559	20.87	271	2,573
Room AC	2.86	43	3,054	4.59	69	4,890
Cent. AC	6.68	80	7,120	11.62	139	12,385
Total	30.37	445	12,823	53.53	796	22,039

TABLE XI
APPLIANCE STANDARDS ANALYSIS
ENERGY SAVINGS SUMMARY

	Savings by 1995		Savings by 2000	
Product	Annual (TBtu/yr)	Lifetime (Quads)	Annual (TBtu/yr)	Lifetime (Quads)
Refrig	78.55	1.50	159.39	3.02
Freezer	15.64	0.32	29.79	0.62
El. WH	145.36	1.89	240.01	3.12
Room AC	32.36	0.49	52.79	0.79
Cent. AC	76.82	0.92	133.63	1.60
Furnace	68.43	1.57	121.78	2.80
Gas WH	115.04	2.65	190.19	4.37
Gas Range	20.51	0.47	31.83	0.73
Total	553.24	9.81	959.40	17.05

TABLE XII
APPLIANCE STANDARDS ANALYSIS
ECONOMIC SAVINGS SUMMARY

	Savings by 1995			Savings by 2000		
Product	Annual Operation (10^6 $)	Net Lifetime (10^6 $)	Benefit-Cost Ratio	Annual Operation (10^6 $)	Net Lifetime (10^6 $)	Benefit-Cost Ratio
Refrig	378	3,216	3.37	670	5,696	3.37
Freezer	76	813	5.88	128	1,358	5.88
El. WH	727	5,989	8.14	1,068	8,798	8.14
Room AC	167	598	1.53	238	854	1.53
Cent. AC	377	537	1.19	582	829	1.19
Furnace	299	1,912	1.90	471	3,010	1.90
Gas WH	514	4,272	8.67	756	6,280	8.67
Gas Range	95	960	7.09	732	1,325	7.09
Total	2,633	18,297	2.69	4,045	28,150	2.69

Conversely, Geller does raise an interesting argument on manufacturing costs. By eliminating low efficiency, low cost products, the company should eventually profit from higher margin sales on higher cost products. This could reduce estimated costs to the manufacturer and offset the additional costs of standard compliance.

Geller's work does provide the best attempt of the three studies to balance costs and benefits. He incorporates DOE cost data and utilizes a reasonable discount rate of 5% to adjust future costs and benefits. He also recognizes the limitations of his study. [Ref. 24:pg. 117]

> Since the energy and economic savings analysis depends on assumptions regarding manufacturer and purchaser behavior in the future in both the marketplace and standards scenarios, the analysis is inherently uncertain. ... However, with stagnant energy prices now and in the near future, efficiency improvements in the marketplace may be less than recent trends and near-term expectations.

Geller's work, like other studies, does not provide economic justification for any specific standard efficiency level. Instead, technically feasible efficiency levels are assumed based on State and trade standards. In view of the uncertainties with regard to consumer behavior and unaddressed consumer welfare costs, the benefit-cost ratios would indicate that standards are set too strict. In the case of water heaters, benefit-cost ratios in excess of eight prove the point.

However, taking into account the political and national influences, the sheer magnitude of the savings are impossible to ignore. Tables VI thru XII provide ample data to logically support his argument that Federally mandated energy efficiency standards are necessary in the market for home appliances.

Consumer welfare loss and the effect of energy efficiency standards on the market for hot water heaters will be the focus of the next chapter.

IV. EFFECTS ON MARKET FOR HOME APPLIANCES

A. INTRODUCTION

What effect do Federal energy efficiency standards have on the market for home appliances and more specifically the market for hot water heaters? Is the free market for home appliances efficient or inefficient? To answer these questions and discuss consumer welfare loss, two recent studies will be utilized. First, a 1987 research report by Henry Ruderman, Mark D. Levine and James E. McMahon, entitled The Behavior of the Market for Energy Efficiency in Residential Appliances Including Heating and Cooling Equipment, will be analyzed. Then, The Incidence of Welfare Losses Due to Appliance Efficiency Standards, a paper by Mark F. Morss, will be examined. Although the two studies differ in assumptions of free market efficiency, they are critical in pointing out factors which are key to economic evaluation of Federally mandated energy efficiency standards. Moreover, they identify unresolved factors that require further research.

B. THE MARKET FOR HOME APPLIANCES IS INEFFICIENT

Ruderman et al., examined the behavior of the market for home appliances over a period from 1972-1982. The study compared improvements in appliance energy efficiency to costs, expecting to find a positive correlation between the two. [Ref. 25:pg. 101]

> To the extent that the market place is effectively influencing the purchase of energy-efficient household appliances, there is little need for Federal policies to modify market forces. To the extent that the market for energy efficiency is not performing effectively, a justification for policy intervention can be supported.

From their results they concluded that the market placed less value on energy savings then desired. This assumes that maximum energy savings at the minimum price is the desired goal.

Key to their approach was analysis based on the aggregate discount rate. [Ref. 25:pg. 103]

> The aggregate discount rate quantifies the behavior of the market as a whole: the manufacturers of appliances, the wholesalers and retailers who distribute them, the third-party appliance installers such as builders or plumbers, and the individual purchasers.

The study assumed that all parties would optimize their efficiency choices. By treating the market as a sum of the optimized choices, a comparison to average consumer discount rates could be done. If the consumer and market discount rates varied significantly this would indicate market inefficiency and conversely, similar rates would back the case for an efficient home appliance market. The strength of this approach is that short term fluctuations in price or demand would be averaged out in the long run using the aggregate market discount rate. [Ref. 25:pg. 111]

Other assumptions used in the study included:

1) Stabilized average fuel costs
2) Non-inclusion of heat pumps in appliance efficiency design options
3) Excluded maintenance costs for appliances

Fuel prices were averaged based on 1972-1982 DOE data and converted into 1980 dollars for usage in the study. The exclusion of heat pumps as an efficiency design option stemmed from using data from the DOE Engineering Analysis Document examined in Chapter III. Maintenance costs were assumed to be small although no data was available to confirm this assumption.

Tables XIII and XIV show the results of their work.

TABLE XIII
AGGREAGATE MARKET DISCOUNT RATES FOR APPLIANCES, 1972-1980 (based on ADL cost-efficiency curves)

Appliance	1972	1978	1980
Gas central space heater	39	51	56
Oil central sapce heater	52	78	127
Room air conditioner	20	22	19
Central air conditioner	19	25	18
Electric water heater	587	825	816
Gas water heater	91	146	166
Refrigerator	105	96	78
Freezer	379	307	270

TABLE XIV
PAYBACK PERIOD IN YEARS FOR APPLIANCES,
1972-1980 (based on AdL cost-efficiency curves)

Appliance	1972	1978	1980
Gas central space heater	2.98	2.38	2.21
Oil central sapce heater	2.33	1.70	1.18
Room air conditioner	5.11	4.77	5.25
Central air conditioner	4.96	4.16	5.18
Electric water heater	0.48	0.41	0.41
Gas water heater	1.50	1.07	0.98
Refrigerator	1.35	1.45	1.69
Freezer	0.60	0.67	0.72

These discount rates were calculated for each appliance based on a single-cost efficiency curve for the period 1972-1980. They are presented in a percent per year basis.

Ruderman et al conducted sensitivity analysis with regard to changes in energy price and its effect on the discount rate. The discount rate is most sensitive to changes in (EF) with uncertainty levels estimated at 5% or less. [Ref. 25:pg. 114-115] No provision was made for escalating energy rates. Higher energy rates would increase discount rate percentages. A cross check with historical data confirmed the general trends shown in Tables XIII and XIV.

Ruderman, Levine and McMahon observed that discount rates were high and that payback periods for most appliances were two years or less. Water heaters had especially high market discount rates compared to other appliances. This would tend to indicate consumers indifference to more efficient water heaters if purchase costs increased. [Ref. 25:pg. 104]

> Because the discount rates of consumers are not known, they must be inferred from the behavior of the market. A high discount rate implies that the operating costs are weighted less heavily because their present value is less. Thus a consumer with a high discount rate would prefer a cheaper, less efficient product to an expensive more efficient one.

This assumption should be tempered with the inclusion of other factors such as manufacturers, and government and industry action which could effect the market.

The high discount rates shown in Tables XIII and XIV could be attributed to lags in market product and price adjustment. Long lead times would tend to exacerbate this problem, although the authors contend that discount rates would still be high. [Ref. 25:pg. 116]

> For those appliances with aggregate discount rates higher than 100 (water heaters), efficiency measures that pay for themselves in less than one year were not in the average product purchased in 1980.

While the energy efficiency factors (EF) associated with water heaters improved over the period from 1972-1982, it was not enough to positively effect the market for hot water heaters to the degree that standardization was required.

Based on the data they compiled, Ruderman, Levine and McMahon concluded that the market for home appliances was not performing efficiently and cited the following possible reasons: [Ref. 25:pg. 116-117]

1) Lack of information about cost and benefits of energy efficiency.

2) Difficulty in obtaining the additional capital to purchase more expensive energy efficient equipment.

3) Expected savings too small to be of interest to the purchaser.

4) Prevalence of third party purchasers.

5) The loading of highly efficient equipment with other features or a scarcity of highly efficient equipment.

6) Long manufacturing lead times.

7) Marketing strategies that may discourage the purchase of more efficient products.

The seven reasons cited prevented the free market from performing efficiently in balancing desired efficiency levels with desired costs.

With rising energy demand and costs, an efficient market for home appliances would have reflected these inputs in the form of more energy efficient products at higher costs without government regulation. This apparently was not the case as shown by the study. [Ref. 25:pg. 121]

> This work indicates that the behavior of the market for energy efficiency has been relatively unchanged from 1972-1980 in spite of large changes in energy awareness and the rapid rise in residential energy prices over this period.

Ruderman, Levine, and McMahon's study objectively disagreed with the assumption that the free market for home appliances was efficient. They made a logical case for governmental establishment of minimum quality or performance standards as a method of ensuring the economical utilization or consumption of a scarce resource-energy.

C. THE MARKET FOR HOME APPLIANCES IS EFFICIENT

If the market for home appliances were efficient, then Federal intervention would not be necessary. Free market forces would theoretically respond to consumer demand for more efficient home appliances. The rising price of energy should be matched by the availability of higher energy efficient products thus optimizing consumer tradeoffs.

In his paper entitled, The Incidence of Welfare Losses Due to Appliance Efficiency Standards, Mark F. Morss supports the view that the market for home appliances is efficient. In arriving at this conclusion, he refutes Ruderman's position based on several points.

First, he argues that Ruderman's analysis was based on data that reflected quantity adjustments but not price adjustments that could have provided market equilibrium. [Ref. 26:pg. 112]

> They assume that variable quantities of appliances of given efficiency could have been supplied at constant prices. However, if the short-run marginal costs of appliances were increasing, then price adjustments as well as quantity adjustments looked for by Ruderman et al. Would have equilibrated the 1972-1982 appliance markets.

This criticism of pricing assumptions is supported by Geller's analysis highlighted in Chapter III. [Ref. 23:pg. 149] Usage of DOE incremental pricing data was also criticized by GAO in their analysis of the DOE's Engineering Analysis Document. [Ref. 4:pg. 160]

Second, Morss argued that energy suppliers have incentives to provide energy data to consumers that would help them optimize energy efficiency choices. Conservation of energy through energy efficiency would lower demand for new power plant construction and aid in energy demand forecasting. This would overcome Ruderman's position that appliance markets were inefficient based on a lack of information. While utility companies have incentives to provide information that would assist consumers in efficient energy consumption, they do not yet provide an itemized breakdown of energy usage by appliance in the monthly utility bill.

Further, existing consumer education programs, such as the EnergyGuide appliance labeling program and rebate programs have had limited success in effectively providing efficiency information to consumers. [Ref. 27:pp. 1-7]

Finally, Morss argues that in the short-run it is in the landlord or contractor's best interest to provide more efficient appliances. He argues that landlords and contractors are using energy efficiency as a marketing tool to compete against one another. This opposes Ruderman's position that indirect purchase decisions or third party purchasers contribute to market inefficiency.

As shown in Chapter II, third party consumers do not have incentives to purchase higher efficiency appliances. Purchase cost or first cost is the relevant cost consideration that effects their profit margin. In the case of upgrading an old water heater to the latest heat pump model, Geller estimated an additional increase in purchase cost of $1200. (See Table V) Is it rational to think that a landlord or contractor, who is not paying the monthly bills, will go for such a deal?

Based on the discussion of Ruderman et al. and Morss's work, it appears that the market for home appliances and more specifically the market for hot water heaters has been inefficient. Ruderman's data reflects low increases in efficiency during periods of high energy rate escalation. From an economic perspective the market did not appear to adjust to a new standard of efficiency.

The arguments raised by Ruderman et al., such as lack of consumer information and prevalence of third party purchasers are rational and reflect the commonly held perception of environmental, utility, Congressional and industry standard proponents that Federal standards are necessary to help the market seek equilibrium at a desired efficiency versus cost level. They are also consistent with economic theory describing a need for governmental regulation in the face of market failure. [Ref. 1:pp. 71-80]

D. EFFECTS OF STANDARDS ON THE MARKET FOR APPLIANCES

The effect energy efficiency standards would have on the market for home appliances appears to be significant. Because standards are to be implemented slowly over a varied lead-in period, dependant on the product, the quantifiable effects of standards on the market for home appliances are unknown. For example, in the case of water heaters, full implementation of standards occurred in January of 1990. It is too soon for reliable historical data to be available for analysis. It is difficult to segregate industry data between costs associated with standards and those industry would have incurred to be competitive in the appliance market. When industry data is available, energy price, energy demand, and manufacturer's costs would provide interesting comparisons to the forecasted costs and benefits assumed in the creation of standards.

The implementation of energy efficiency standards can effect the market in several ways. Third party consumers will be forced to use higher efficiency appliances, saving energy, although it is hard to estimate at what magnitude due to consumer behavior factors outlined in Chapter II. Manufacturers could benefit from elimination of lower efficiency, lower profit margin product lines and concentrate on higher efficiency product lines. The increase in costs related to design option efficiency improvements would likely be passed on to the consumer maintaining desired profit margins. Manufacturers would also benefit from economies of scale as they no longer have to produce the range of product lines to meet varied State standards.

Lower income consumers will bear the brunt of the impact of standards. Higher purchase costs with resultant longer payback periods would effect consumers with the lowest energy demand. This low energy demand results from consumer budget constraints. High purchase cost would also discourage replacement of older inefficient appliances.

In his paper, Morss points out that consumer welfare loss is a cost associated with standards. Welfare costs are a cost which were not included in the economic evaluation of standard implementation. [Ref. 27:pg. 111]

> It is shown that the households most likely to prefer less efficient appliances, and therefore to suffer welfare losses when standards are imposed, are those with low levels of appliance usage.

Here the purchase costs are high to a portion of the population that proportionately uses lower amounts of energy due to budget constraints.

Morss goes on to point out an example of how standards would effect water heater purchase decisions. [Ref. 27:pg. 115]

It is intuitive that a household using a great deal of hot water would choose a more efficient water heater than a household using little hot water, since the latter household has less to gain from purchasing increased efficiency.

This suggests that an unknown proportion of low income consumers would optimize their choice with regards to energy efficiency by purchasing less efficient water heaters. Low income consumers would appear to have a much higher discount rate than the market rate. Budget constraints and perceived return on purchase costs are overriding factors that the low income consumer would consider in optimizing his/her efficiency choices.

The magnitude of costs levied via higher first costs on lower income/low energy consumers is unknown. Welfare costs could adversely impact benefit-cost ratios especially in the case of air-conditioning whose B/C ratio was already close to 1.0.

Several factors that are key to analyzing the market for home appliances remain ambiguous. Consumer welfare costs and consumer behavior,(as outlined in Chapter II), contribute to uncertainty in assumptions concerning market behavior. Further study in these areas is needed. This, coupled with research into what operating savings levels would be attractive to consumers, would go a long way to removing the ambiguity from assumptions about the market for home appliances. The real costs and benefits could then be ascertained.

Next, Chapter V will focus on enforcement procedures and the costs associated with certification and testing programs.

V. CERTIFICATION AND ENFORCEMENT

A. INTRODUCTION

How are energy efficiency standards enforced and what are the costs involved? To answer this question, the National Appliance Energy Conservation Act of 1987 and the Consumer Products Efficiency Standards Engineering Analysis Document were utilized. These two documents highlight the policy and procedural guidance for the DOE's certification and enforcement program. Additionally, they estimate the associated costs that would be incurred in the certification and enforcement of energy efficiency standards in home appliances.

B. CERTIFICATION

Products are divided into two separate groups in the certification process - low production volume models and basic models. In the case of water heaters, low production volume is production levels of 250 or less per year. Low production volume models are deemed compliant to energy efficiency standards if each unit equals or exceeds 95% of the applicable standard. Basic models were to be certified in accordance with established Federal Trade Commission guidelines for testing and sampling as outlined in 10 CFR Part 430 Subpart B (FTC Sampling Plan). [Ref. 19:pg. F-2]

By establishing a two-tiered testing and certification program, DOE helped reduce certification costs to the small manufacturer. This was a response to the small manufacturer's complaints that large scale certification and testing procedures would put small manufacturers out of business. [Ref. 19:pg. F-13]

> Certification testing was also said to unduly increase the costs of basic models with low production volumes. For example, certification test costs that represent 1% percent of the factory value of a basic model with an annual production of 1,000 units would represent 20% of the factory value of a basic model with an annual production of only 50 units.

The result was that small manufacturers would need to test one half of the average estimated sample size for testing under FTC guidelines. [Ref. 19:pg. F-14] This helped to equate the certification and testing costs between large and small manufacturers on a per unit basis.

C. ENFORCEMENT

DOE enforcement policy relies on market queuing to identify non-complying manufacturers. An elaborate national network of enforcement agencies and inspectors was deemed too costly. Instead, DOE relies on sources of information such as the FTC labeling program, industry testing programs, consumers and the manufacturers themselves. [Ref. 19:pg. F-16]

If DOE has indications that a specific model may not be in compliance with the applicable energy efficiency standard, a notice is sent to the manufacturer outlining the model to be tested, the method for selecting a test sample and the facility that will be utilized for testing the model. (Ref. 19:pg. F-8) The DOE inspector then selects a batch of up to 22 units from the sample. Individual test units are then randomly sampled for compliance to the rated energy efficiency standard for the product. [Ref. 19:pg. F-8]

> 22 is selected as the batch number under the assumption that this provides adequate provision for test unit failures while giving the manufacturer a known max value for the number of units to be retained in the batch sample.

Under DOE guidelines, distribution would cease immediately if products were found in non-compliance with standards. The manufacturer would have to re-certify the product before distribution could begin again. A fine of no more than $100 per unit could be assessed on the manufacturer who knowingly produces appliances not in compliance with the energy efficiency standards. [Ref. 20:pg. 47] A DOE commission would assess the penalty via written notice to the manufacturer. DOE estimated that enforcement testing would be conducted on less than 1% of the covered basic models in any year. [Ref. 19:pg. F-16]

D. COSTS

The costs associated with standard certification testing and enforcement are split between the industry and DOE. Generally, certification costs are borne by the manufacturers while enforcement costs are assumed by DOE. This parallels where the product is tested, with most certification testing occurring at the manufacturer's facilities and most enforcement testing occurring at independent test laboratories selected by DOE. [Ref. 19:pg. F-30]

Table XV shows the estimated annual FTC and DOE certification and enforcement costs to the manufacturers.

TABLE XV
ANNUAL FTC AND DOE CERTIFICATION

AVERAGE ANNUAL FTC AND DOE C/E COST TO MANUFACTURER			
FTC COSTS	TOTAL (000)	% OF FACTORY VALUE	PER UNIT SHIPPED
WATER HEATERS	$393	0.07	0.07
ADD COSTS OF DOE C/E PROG	$17	0.003	0.002
TOTAL FTC AND DOE C/E COSTS	$410	0.073	0.072

SOURCE DOE/CE-0030

These certification and enforcement costs vary from the 11 cents per unit C/E cost assigned to manufacturers costs in

Chapter III. This can be explained by revisions in DOE's approach to the C/E program. In DOE's Consumer Products Efficiency Standards Analysis Document, the certification and enforcement program required more documentation and monitoring of manufacturers then the revised C/E program. Existing manufacturer's costs associated with FTC compliance were assumed to be unchanged.

The total additional costs of the DOE C/E program to the home appliance industry would be in excess of $231,000 dollars. This is in excess of existing FTC testing costs. Water heater manufacturers would assume $17,000 of this total. Water heater manufacturers appear to be less sensitive to C/E initiatives when compared to other home appliances. Central air conditioners and Furnaces account for the remaining $214,000.

Overall, the DOE's C/E program, as outlined by the National Appliance Energy Conservation Act of 1987 and the Consumer Products Efficiency Standards Engineering Analysis Document, does not appear to significantly impact the hot water heater manufacturer. This assumption is consistent with DOE's approach to utilizing existing FTC product testing programs and voluntary manufacturer product testing to keep certification and enforcement costs down.

Additionally, by not setting up a regional or state C/E apparatus, the DOE saves dollars. This program would appear to rely heavily on the industry, state energy conservation offices, consumers and local building code inspectors to help identify non-compliant products.

The decision to implement a C/E program was predicated by the assumed passage of the energy efficiency standards. Whether the costs of C/E outweigh the benefits is therefore a moot point. It does appear that DOE approached the issue of certification and enforcement with fiscal constraint and logic.

VI. SUMMARY/CONCLUSIONS/RECOMMENDATIONS

A. SUMMARY

This study has explored the economic evaluation process associated with the establishment of national energy efficiency standards for home appliances. Hot water heaters, one of the 13 home appliances effected by standards, provided a representative analysis point to assess the effects of government regulation on a free market. Testimony of key proponents and opponents of standards, along with comprehensive studies and articles on energy efficiency, provided a framework for analysis.

B. CONCLUSIONS

While it is hard to separate economic arguments from political and technical influences, this study has sought to identify economic factors that effected product design choice. Although assumptions concerning cost and savings projections vary, the magnitude of energy savings possible are too large to question. Energy conservation arguments bring a national scope to the problem of standard implementation. This appears to be a rare case in which the regulated (home appliance industry) wished to be regulated by a reluctant Federal government. Normal free market resistance to Federal regulation was not readily apparent due to State energy efficiency standard development. It was better for the industry to have one standard then many State standards.

Based on representative data highlighted in this study, it appears that the market for home appliances was inefficient. Classic economic indicators of market failure, such as information failure and externalities, would then appear to justify the need for federal intervention in the free market for home appliances.

C. RECOMMENDATIONS

Analysis has identified several areas that need further study. First, consumer welfare costs remain an unknown factor, not quantified in the representative studies examined. These costs could be significant in that low income consumers bear a proportionately higher share of the cost of standardization while theoretically consuming less of the "saved" energy. Second, consumer behavior with regard to energy efficiency optimization, remains an uncertainty that could impact cost and savings assumptions. For instance, what level of operating savings would the consumer require to overcome a higher level of purchase costs? The answer to this question would be essential to any justification of standard setting. Perhaps there is not a quantifiable answer to this and other predictions of consumer behavior. Until these two issues are addressed, further analysis of the balance of costs and benefits associated with energy efficiency will be based on varied and sometimes questionable assumptions.

Additionally, further study could concentrate on the question of whether standards are the best method for government intervention in the home appliance market. Alternatives, such as taxes, subsidies and incentive programs merit evaluation. Perhaps these alternatives could be more cost effective or save higher levels of energy without restricting the home appliance industry.

The question that still remains unanswered is what level of energy efficiency is optimal? Political and technical influences can be factors in this answer. Economically the efficiency level that equates to a balancing of marginal costs and marginal benefits would approximate the appropriate energy efficiency level. Perhaps then, and in isolation of political and technical influences, could a economically justifiable standard be set.

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